

UROP Final Report
Design, Development, and Installation of a Sustainable Concrete Sidewalk for the UMD
Campus

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Summary

The UMD Campus Master Plan has a guiding principle of visibly manifesting sustainability and a goal of creating a bicycle and pedestrian friendly campus. In order to achieve that goal, new sidewalks will have to be constructed on future projects. Concrete sidewalks can be more sustainable by using less portland cement, the binding material used in concrete. Concrete is widely used throughout the world and it is estimated that the production of portland cement for concrete accounts for 5-7% of the global anthropogenic greenhouse gas emissions. Therefore using less portland cement in concrete can lead to a more sustainable concrete product that UMD can use for sidewalk construction.

To make up for the losses of having less portland cement, supplementary cementitious materials (SCMs) are used. These materials include: fly ash, slag, silica fume, metakaolin, and glass. These materials are considered carbon neutral as they are by-products of other industrial processes. A UROP last fall tested concrete mixtures with a high replacement rate for each SCM. The concrete mixtures were tested for compressive strength, freeze thaw durability, and global warming potential (amount of carbon dioxide emitted for production). The results from fall semester found that glass and metakaolin are not a viable replacement for a sustainable mixture when compared to slag, fly ash, and silica fume. Fly ash and slag can both have up to a 40% replacement rate of portland cement. Silica fume provides freeze thaw durability and early compressive strength. The test results served as a baseline for combining SCMs for the spring semester UROP.

The UROP for the spring semester focused on combinations of fly ash or slag and silica fume with varying replacements to improve upon the sustainability of the fall semester results. The mixtures were tested for compression, freeze thaw durability, and global warming potential.

Results

Every mixture containing fly ash underperformed in the freeze thaw chamber at high replacement rates. A mixture of 40% slag and 10% silica fume was found to be a reasonable replacement for concrete sidewalk mixtures. The two SCMs work to complement each other. The high content slag will not affect the compressive strength and performed better in the freeze thaw chamber than fly ash. The silica fume helps provide freeze thaw durability and early compressive strength. This mixture has a total cement replacement rate of 50% which would reduce the total carbon emissions by over 40% of typical concrete with no replacement. A mixture of 50% slag and 10% silica fume could be used but under performed in freeze thaw durability compared to the 40% slag mixture.

The next phase of this project is to install test slabs in on the UMD campus. Every year small sections of sidewalk are replaced because they are cracked or do not pass ADA standards. This provides an opportunity to install a test slab in a real setting. The slabs will be inspected over the next year or two for cracking or scaling and then evaluated if the concrete mixture is good enough for UMD to use for future construction projects. With grant money from Dr. Mary Christiansen and coordination from Erik Larson in facilities management, we should be able to install slabs this summer of 2015.

Educational Objective

This semester, my educational objective was to efficiently improve upon my testing plan when compared to last semester. Last semester I learned that freeze thaw testing takes much longer than I thought it would. My other objective was to effectively present my findings at four different conferences. I gave an oral presentation at an American Concrete Institute convention in Kansas City, National Conference for Undergrad Research convention in Spokane, UMD UROP showcase, and a SELF-Sustain conference in Crookston. These presentations were a very good experience and I learned a lot from the professional community as well as fellow undergraduates.

Evaluation

My UROP experience this semester has been more rewarding than last semesters UROP. This semester I got to travel and present my research. The University is very generous and supportive of students traveling to conferences to present. Overall this whole experience has enhanced my educational experience at UMD. I look forward to hopefully implanting this research on future projects at UMD.